CONSERVATION ASSESSMENT OF INVERTEBRATE ASSEMBLAGES: IS THERE A PLACE FOR GLOBAL LEVEL TAXON-FOCUSING?

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The massive diversity of invertebrates, lack of taxonomic and ecological knowledge of most groups, and the low likelihood of greatly increased logistic capability to acquire this, ensure that conventional 'inventory' approaches to assessing magnitude and patterns of species diversity in natural assemblages will remain unfulfilled. In order to incorporate invertebrates meaningfully into a broad range of conservation assessment and management, some form of 'triage' seems inevitable. Possible grounds for concentrating on a restricted 'umbrella suite' of ecologically-important taxa are discussed.□*Inventories, conservation priorities, keystone taxa, indicator taxa, umbrella taxa, flagship taxa.*

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Many biologists now accept readily that impending major loss of biodiversity, equated most commonly to loss of species, is the predominant crisis facing our natural world in the next few decades and that this must be countered with the best means at our disposal. The vast, and largely unheralded, proportion of this loss will comprise invertebrate animals, whose central roles and values in contributing to sustainability of natural ecosystems are only now becoming appreciated, and for which our knowledge of diversity and distribution is minimal. Documentation and quantification of invertebrate assemblages may be regarded as a central theme in understanding 'biodiversity', and some people have argued that such knowledge is a *prerequisite* for effective conservation. However, the ideals espoused by such a stance - of collecting and describing *all* taxa of invertebrates in marine, terrestrial or freshwater assemblages as a basis for determining patterns of distribution and abundance are utopian for invertebrates as a whole and for most taxonomic groups, not least because of the decline of the taxonomic workforce and of support for 'basic' ecological surveys at all levels. It is indeed anachronistic that, at a time when the practical need for documenting faunas adequately, as basic information used in setting priorities for, and implementing, conservation management is being espoused globally as a basis for assuring global sustainability, our capability to do this is being eroded.

The urgent needs for documenting invertebrate assemblages adequately are (1) to understand the template against which we can appraise effects of anthropogenic change, (2) to increase appreciation of the ecological importance of invertebrates, and logistic support for their conservation, and (3) to apply that support in the best way(s) possible to increase management capability based on sound science and ethics. But the constraints noted above are likely to increase, and there is little realistic prospect of (for example) doubling or tripling the taxonomic workforce, or of diverting a significant proportion of the 'conservation dollar' from vertebrate issues to the assessment of largely undocumented and non-charismatic taxa or communities. We must, of course, continue to emphasise the need for increased scientific and logistic capability (and urge massively greater funding for taxonomic work), and of the underpinning role of taxonomy and collection management and interpretation as a vital tool for conservation assessment - but, also, must not let this need prevent us from making progress.

It thus seems inevitable that our rationale in seeking to document invertebrate assemblages must change, and must be adapted to accept substantial constraints and to advance our scientific capability as effectively as possible. The invertebrate conservation community must become more positive, and (whilst we must continue to bemoan lack of optimal capability) seek to make rapid progress in selected areas rather than continuing to foster the dilute approach necessitated by trying to document complex assemblages fully, or reasonably fully. One way to achieve this may be to focus our efforts more finely, and to select the most 'rational' (that is, most informative) targets by some form of 'triage', however ethically difficult this might be. Indeed, in most invertebrate surveys some degree of triage is al-

ready employed: we usually select only particular taxonomic groups for analysis, depending on criteria such as our own interest in given groups, ideas about which might give us the 'best' information or, simply, the capabilities of our assistants or whether we have expertise or access to expertise in systematic appraisal of the specimens collected. Such factors in practice already drive and restrict ecological interpretation, and our ability to analyse diverse natural assemblages in terms of the taxa present and for comparative ranking for conservation priority or importance.

However, there are often substantial difficulties in trying to compare surveys based on different taxa or habitats. There is a major need to transform what is at present little more than a series of ad hoc interpretations each depending to some extent on opportunism or local capability and giving prominence to different taxonomic groups, into an effectively assembled and coordinated data accumulation which can eventually give us great capability for comparative assessment of invertebrate assemblages, and which can help us overcome the various 'taxonomic impediments' and 'ecological impediments' which have tended to foster an air of defeatism in recent years.

TAXON-FOCUSING

Perhaps the most effective avenue to progress would be to focus the bulk of our restricted logistic capability on a restricted suite of major taxa, and to deliberately give lower priority to most invertebrate groups. One approach to this (New, 1993) could be to delimit a large 'umbrella suite' of phyla for attention, from which smaller segregates may be selected progressively in a range of different habitats and ecological contexts. New (1993) suggested that perhaps no more than 9 phyla need consideration in order to gain a sound comparative database on distribution, diversity, and ecology relevant to conservation of all (or most) other invertebrate groups. Briefly, the criteria used to delimit such a suite (Appendix 1) seek to capitalise as effectively as possible on the knowledge and capability available. They emphasise (1) the relative knowledge which exists at present and (2) the groups' capability to augment ecological understanding, so that the major 'values' adduced are scientific ones. The groups are those whose incidence and abundance can be used most effectively to assess the wellbeing of communities and ecosystems. The phyla suggested as particularly useful for this exercise are Cnidaria, Porifera, Platyhelminthes (Turbellaria), Mollusca, Annelida, Onychophora, Arthropoda (s.l.), Bryozoa, and Echinodermata. The principle of deliberately de-emphasising most invertebrate phyla or, at least, omitting them from quantitative assessment for conservation is certainly a difficult one to espouse and this 'umbrella suite' is a suggested one only, to demonstrate the principle involved. It includes virtually all invertebrate groups which have been the subject of species-orientated conservation studies or used as indicator taxa; at that level, therefore, this grouping does little more than formalise the status quo. I also emphasise that omission of any group from this suite of preferred taxa does not demean its importance or relevance, or suggest that it is any way 'expendable'. It is not, but many of the poorer known invertebrate groups are likely to be conserved more effectively by being placed under an ecologically comprehensive umbrella than by being appraised individually when this entails a massive 'catch up' operation or is logistically intensive to achieve. By concentrating our efforts on a suite of taxa likely to yield 'high knowledge dividends', many (most) other groups may gain benefit.

The implicit priority is to augment capability for a number of ecologically informative invertebrate groups which are already relatively well known, which have definable ecological values and for which a core of capability is available. We are clearly committed to levels of extrapolation or of generality in seeking to define assemblages quantitatively but need to seek both 'diversity in generality' and 'generality in diversity', emphasising that although we desire to know all the animals present there is no *practical* likelihood that we shall ever do so at any ecologically meaningful level. In essence, invertebrate conservation zoologists have to learn to redress the feelings of academic defeat of not being able to assess total assemblages completely, to move on from arguing about numbers of species per se and to develop a practical framework to safeguard organismal biodiversity on pragmatic grounds. Focussing on particular groups is more likely to enable assembly of a broadly applicable data set within a foreseeable period, than continuing to pursue broader, more academically satisfying but less attainable, goals.

Other, alternative or complementary, approaches are of course possible. Rather than primary delimitation at the phylum level, lower level taxa (orders, families) from a wider range

of phyla could be selected for intensive appraisal. This could indeed incorporate particularly relevant other groups of a wider spectrum of invertebrates whilst not diverting from the main thrust of focusing logistic capability. Either of these approaches (or a combination of them) thus differs markedly from approaches such as 'guild analysis' of assemblages, whereby it may still be necessary to systematically interpret all invertebrate groups and enhance the taxonomic capability to do so.

A carefully-selected 'umbrella suite' of taxa is likely to obviate the need for this.

It could be suggested, as has occurred in some past studies, that all invertebrates may be safely conserved in natural communities by the more 'usual umbrellas' of vertebrates and vascular plants, and that a logical extension may be to ignore them completely in assessment of assemblages. However, there is abundant evidence that the ecological sensitivities of invertebrates in all major ecosystems may be extraordinarily subtle and that their partitioning of resources may be undertaken in very intricate and sensitive ways. Unless they are indeed incorporated in assessment of the 'health' of natural assemblages, much subtlety may be lost simply through ignoring the detailed needs of the predominant components of those assemblages and losing capability to monitor the effects of anthropogenic intrusion. Simply, invertebrate assemblages cannot be assessed properly without assessing invertebrates themselves in any context where broad comparisons may be needed.

Any particular ecological survey may necessitate acquisition of a massive amount of data specific to that study. Its value could be enhanced dramatically if the main data were immediately relevant to, and available for, incorporating into broader national or global comparative scenarios. Di Castri et al. (1992) emphasised the importance of rapid standardised methods for survey for ranking or assessing communities, and this theme pervades other recent discussion (see Spellerberg, 1993, for examples). Di Castri and his colleagues noted that all major trophic groups should be included in the representative taxa used for assessment; that all main size groups, species-rich and species-poor groups, and groups containing common and rare species should be incorporated; and that, for example, '10-15 families of insects' should be included.

Important steps that might now be taken to recognise the need to increase our capability to study natural assemblages include:

i)to discuss the values of 'taxon triage' over any more comprehensive approach;

ii)to gain a broad consensus on the groups of invertebrates we need to assess, or which merit priority, in assessing assemblages in different habitats;

iii)to derive protocols for sampling and assessing those taxa in standard comparable ways (ranging from devising optimal sampling sets to production of identification manuals and sets of voucher material for distribution to users), enabling their use for various forms of ordination analysis, and the sound recognition and delimitation of 'notable' species.

iv)to increase global capability for interpreting the distribution of the priority groups and evaluating their responses to habitat change or other disturbance, and

v)to incorporate information on them into what will eventually become more comprehensive databases useable for both specific and comparative assessment.

DISCUSSION

Optimal taxonomic groups (be they at phylum or low levels of selectivity) in any such scheme of taxon-focusing to enhance invertebrate conservation should be selected in relation to the kinds of ecosystem being assessed and the properties of the species involved. These are inter-related: initial appraisal of major ecosystem categories and comparison between these in different continents and climatic regimes (as suggested by di Castri et al., 1992) is likely to reveal the various suites of invertebrate taxa which will complement each other in general themes of gathering information and increasingly sophisticated use of indicator taxa *as well as* the delineation of critical faunas based on criteria such as high diversity, high endemism or the presence of notable or rare species. The basis for some such survey for many groups is already available in literature.

This approach is not meant to deter species-orientated conservation for threatened taxa of *any* invertebrate group; this is a different exercise from taxon-focusing for defining and setting priorities in assemblages and, clearly, *any* especially notable species has the potential to become an 'umbrella' or 'flagship' in its own right. Generally, the phylum level is too embracing for this—except, possibly, in the case of relatively small and notable groups such as the Onychophora (New, 1994). Onychophora are a group for which the general appearance is unam-

biguous. Their detailed systematics are complex but the mere presence of any species may be sufficient to mark out a forest or grassland site, or a cave, as being of conservation significance. They are potentially useful flagships (and umbrellas) for the multitude of less conspicuous invertebrates, mostly known even less well, which also occur in wet forest habitats, for example. By contrast, many arthropod groups manifest strongly all or most of the features on which other phyla in their entirety have been excluded from the 'umbrella suite': small size, general inaccessibility or difficulty of comprehensive sampling, lack of taxonomic knowledge and agreement, intangible diversity, little ecological knowledge or distributional information, or an entirely parasitic mode of life. These factors can guide us constructively in our selection of focal orders or families within most of the larger phyla. It may be profitable to select some 'taxon sets' on a regional basis, rather than globally, but there should be provision for the greatest amount of comparative assessment possible. For example, incorporation of groups such as tardigrades and rotifers for assessing low diversity Antarctic terrestrial communities (Usher & Edwards, 1986) is rewarding, but these groups may have less relevance elsewhere.

The twin roles of invertebrates in conservation assessment may be summarised as (1) diversity or presence/absence of particular taxa reflecting the complexity or 'health' of natural communities, and (2) monitoring the changes wrought by changed conditions, perhaps more effectively than can be achieved by using other organisms. 'Biological indicators' is a very broad term, but there has been considerable recent interest in selecting groups of invertebrates whose presence or abundance can indeed indicate environmental health sensitively. For examples, Spellerberg (1993) delimited five categories of pollution indicators alone, and a recent volume on benthic invertebrates (Resh & Rosenberg, 1993) demonstrates their wide indicator relevance in freshwater communities.

Any relatively well-known invertebrate group which can embrace values of traditional indicator, flagship or umbrella properties probably merits high priority. *If* it proves possible to delimit keystone groups (reef-building corals are one example), this criterion would be especially important: however, the more general perception of 'keystones' at present tends to be at the species level, rather than the higher taxon. But I believe that it is indeed possible to incorporate such a range of ecological considerations into taxon delimitation, and that the habitat formation is the background against which optimal groups must be decided.

At present the future for invertebrate conservation is in the balance, and prospects for the emerging science are critical. On the one hand we can continue as we are, largely uncoordinated and having heated discussions about levels of diversity and the values of particular species, and–perhaps–seeing our restricted resources diluted to suboptimal ends through lack of focus. On the other hand, we can seek a different or more coordinated focus, involving a level of triage at either the taxon level or the community (or major habitat) level. My comments today are directed to the first of these changes, with the implication that complementarity between the preferred groups will indeed give us a sound understanding of broader aspects of invertebrate assemblages and guide us effectively toward their management.

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APPENDIX

Criteria for designating a suite of invertebrate phyla for priority study to construct data bases for conservation assessment and to act as a broad umbrella suite for conservation of other invertebrates (after New 1993).

1) Include marine, freshwater and terrestrial taxa, and groups crossing these systems in various combinations; all major ecosystems represented repeatedly.
2) All feeding modes and trophic levels replicated, and diverse ways of life represented; emphasis on 'free-living' taxa; all significant ecological roles and interactions, with indicator groups to monitor these, incorporated.
3) Most geographically widespread, but also include local endemics, critical faunas, or 'hot- spots' of diversity in selected range of areas.
4) Most diverse, but with established taxonomic frameworks for all, or significant, sections.
5) Substantial existing ecological information, such as
   i) taxa promoted/used as indicators
   ii) possssibility of expanding from documented existing foci (such as case-studies)
6) 'Values' defined or definable, including range of 'commodity' or 'applied' aspects likely to engender political support.
7) Possibility of incorporating taxa in educational programmes, for example to help overcome prejudice against invertebrates.
8) Amenable to capture/sampling by standard or simple techniques which can be replicated easily and combined into sampling sets. Possibilities for laboratory rearing to facilitate *ex situ* conservation.
9) 'Critical mass' of workers on group exists, with realistic potential for global/ international cooperation and complementarity.
10) Knowledge base founded in museum and other institutional collections can be used to document the critical nature and define distributions for selected taxa.